Development of an information system for cycling navigation

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Abstract

This study develops an information system for cycling navigation based on seven different bikeability indicators: travel time, energy expenditure, effort distribution, infrastructure performance, safety, comfort and emission hotspots. Therefore, field data were collected in a selected cycling network map of Aveiro, Portugal, during the weekdays' afternoon peak hour period. A conventional aluminum bicycle equipped with a GNSS data logger, a wireless heart rate recorder device and a video camera were used. Using the defined methodologies as well as GPS Visualizer and ArcGIS, a total of 8 hours of video and approximately 100.000 second by second data points were analyzed and organized through a 449-link map. Through three case studies, several optimal solutions for different OD pairs were studied using Dijkstra's shortest path algorithm. Results show significant tradeoffs between the traced routes according to the chosen type of indicator, pointing the information system' utility in providing useful information to cyclists and support management systems.

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1. Introduction and objectives

With the possibility of providing data on new variables related to bikeability, intelligent cycling information systems started to emerge. These tools revealed to be ultimately essential to enhance the use of bicycles, either through its ability to assist a cyclist in the route choice process effectively, support systems at the policy level or improve attractive bike-sharing systems (Cruz et al., 2020). The main objective of this paper is to develop a specific information system for cycling navigation, based on a geographic information system (GIS) and using seven different indicators: travel time, energy expenditure, effort distribution, infrastructure performance, safety, comfort and emission hotspots.

2. Methods

A data collection process was carried out through empirical monitoring and on historical data assessment. Then, a map data analysis was performed on a GIS platform. Finally, routes were optimized in several case studies according to multicriteria analysis (based on different attributes). The final indicators' attributes and its formulations were defined in terms of required inputs. Overall, the attributes of the travel time, safety and comfort indicators were obtained more directly, while those of energy expenditure, effort distribution, infrastructure performance and emission hotspots were calculated indirectly through more detailed mathematical methods.

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3. Results and Conclusions

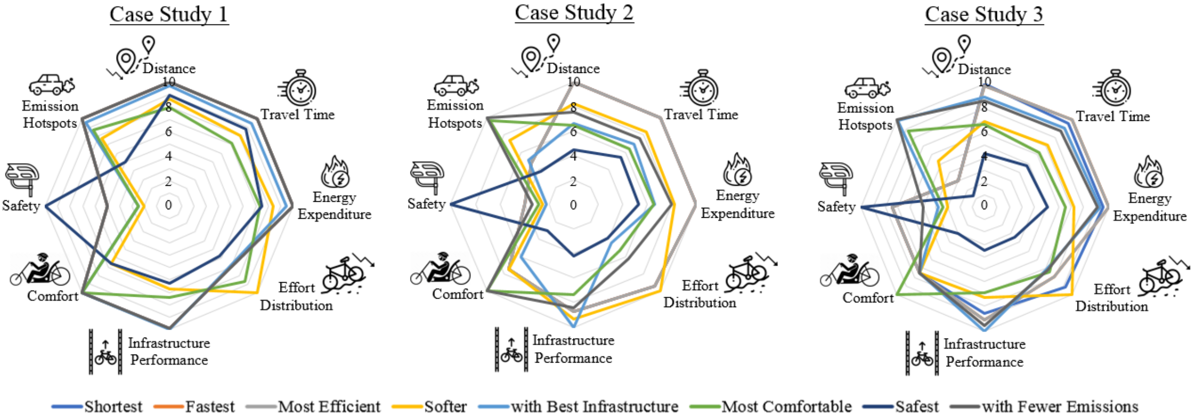

Figure 1. Spider charts of tradeoffs illustration between routes and indicators for all three case studies.

Two analysis tools were built: a table of relative relationships showing, for each optimization how the remaining factors (rows) are negatively affected concerning their individual best performance, and three spider charts (figure 1) which allow the visualization of tradeoffs by scoring the indicators on a scale from 0 to 10.

The following major conclusions were drawn:

- Although often coincident, the fastest route was 2% longer than the shortest route in case study 3, demonstrating the inclusion that time travel indicator makes of waiting times, intrinsic to the road network. In its turn, energy expenditure was always equal to travel time, thus proving to be more useful as additional information of the traced routes by the system rather than an impedance.
- Except for safety, all indicators gave origin to unique and balanced routes. In fact, compared to the best values, the safest route was, at least, 50% longer and more time consuming, with several overtaking maneuvers (400% higher) and a 350% worse BLOS score. Therefore, the attribute of this indicator must be improved or changed.
- The achieved attributes conveniently characterize the studied road network, adapting to the links according to their traffic volume: more time preserving indicators will make priority use of arterial and collector roads, while comfort-related indicators will mainly choose residential streets.

All the collected data and ArcGIS graph of this research is available online in Zenodo (Lé de Matos et al., 2020).

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References

Cruz, R., Bandeira, J., Vilaça, M., Rodrigues, M., Fernandes, J., & Coelho, M. C. (2020). Introducing new criteria to support cycling navigation and -infrastructure planning in flat and hilly cities. Transportation Research Procedia, 47, 75-82.

Lé de Matos, F., Fernandes, J. M., Sampaio, C., Macedo, J., Coelho, M. C., Bandeira, J. (2020). Information System for Cycling Navigation for Aveiro, Portugal - Database and ArcGIS Graph [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3870836